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Development of empirical data sets to further constrain glacial modeling in southwestern Greenland

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Direct dating of the retreat of the southwestern margin of the Greenland Ice Sheet (GIS) coupled with spatial analysis and glacial modeling have the potential to better constrain the timing of the retreat of the ice margin, the thickness of the former ice sheet as well as its response to climate change.

We measured ^{10}Be concentrations in 12 samples collected along a longitudinal and altitudinal transects from Sisimiut to within 10 km of the Isunguata Sermia Glacier ice margin on the southwestern coast of Greenland. Along the longitudinal transect, we collected three perched boulders and two bedrocks. In addition, seven perched boulders were sampled along a vertical transect in a valley within 10 km of the Isunguata Sermia Glacier ice margin. The results constrain the height of the ice sheet during the last glacial maximum (LGM) between 500 m and 840 m (including the 120 m relative sea level depression at the time of the LGM, 21 kyr BP). From the transect we estimate the thinning of the ice sheet at the end of the deglaciation between 12.3 $\pm$ 1.5 ^{10}Be kyr (n = 2) and 8.3 $\pm$ 1.2 ^{10}Be kyr (n = 3) to be $\sim$6 cm.yr^{-1} over this time period.

In addition, we conducted a spatial analysis of the lake shape distribution, an important geomorphological indicator in previously glaciated areas. Since glacial sediment deposition or erosion act on large areas, distribution of lakes can reflect the intensity of glacial erosional/depositional processes and their spatial extent. Landsat imagery was used to extract lake outlines from our study area on the widest ice-free coastal margin of the southwestern Greenland north of Kangerlussuaq. Analysis included image classification and spatial analysis of lakes with elevation data using geographic information system tools. A morphometric index was applied to extract kettle lakes as indicators of a specific glacial process – ice stagnation. The analysis shows that the highest concentrations of lakes within the study area occupy the elevation range between 164 and 361 m above sea level. This conclusion is supported by the above surface exposure ages. The widespread distribution of modeled kettle lakes within the same elevation range and across the study area suggests that the last deglaciation process was accompanied by abandonment of blocks of stagnant ice.

Our data are now being fed into the next generation of numerical reconstructions, using parallel ice sheet models, capable of closely replicating the range and pattern of ice flow velocities observed in the present GIS at high horizontal resolution (1-5 km). Ice thickness simulations by recent models are within the range of 1,100 – 1,300 m over the last deglaciation, largely overestimating our empirical and analytical results. The goals of this and future studies are (1) to test the overestimated glacial reconstructions (height of the ice sheet) of the southwestern sector of the GIS proposed by the current models and (2) to reconstruct the deglacial history of the region.